Claims

1. A phosphor comprising a crystal phase having any one chemical composition of the following formulas [1] to [4]:

$$Eu_{a0}Mn_{b0}M^{10}{}_{c0}M^{20}{}_{d0}M^{30}O_{e0}Z^{0}{}_{f0} \quad [1]$$

wherein M^{10} is a divalent element containing 85 mol% or more of at least one element selected from the group consisting of Ba, Ca and Sr, in which the ratio (molar ratio) of Ca to the sum of Ba and Ca is from 0.1 to 0.9; M^{20} represents at least one element selected from the group consisting of a monovalent, trivalent and pentavalent elements; M^{30} represents a group of tetravalent elements containing Si and Ge in a total amount of 90 mol% or more; Z^{0} is at least one element selected from the group consisting of a minus monovalent and minus divalent elements, H and N; and a0 is a number satisfying $0.001 \leq a0 \leq 0.6$, b0 is a number satisfying $0 < b0 \leq 0.7$, c0 and d0 are numbers satisfying $0 \leq d0/(c0+d0) \leq 0.2$, a0, b0 c0 and d0 are numbers satisfying $1.8 \leq (a0+b0+c0+d0) \leq 2.2$, and e0 and f0 are numbers satisfying $0 \leq f0/(e0+f0) \leq 0.035$ and $3.6 \leq (e0+f0) \leq 4.4$:

$$Eu_{a1}Mn_{b1}Mg_{c1}M^{11}{}_{d1}M^{21}O_{e1}Z^{1}{}_{f1} \quad [2]$$

wherein M^{11} represents at least one element selected from the group consisting of a monovalent element, a divalent element except Eu, Mn and Mg, a trivalent element and a pentavalent element, in which the proportion of the divalent element is 80 mol% or more, the proportion of the sum of Ba, Ca and Sr is 40mol% or more, and the ratio (molar ratio) of Ca to the sum of Ba and Ca is from 0.2 to 0.9; M^{21} represents a group of tetravalent elements containing Si and Ge in a total amount of 90 mol% or more; Z^1 is at least one element selected from the group consisting of a minus monovalent and minus divalent elements, H and N; and a1 is a number satisfying $0.001 \leq a1 \leq 0.8$, b1 is a number satisfying $0 < b1 \leq 0.8$, c1 and d1 are numbers satisfying $0 < c1/(c1+d1) \leq 0.2$, a1, b1 c1 and d1 are numbers satisfying $1.8 \leq (a1+b1+c1+d1) \leq 2.2$, and e1 and f1 are numbers satisfying $0 \leq f1/(e1+f1) \leq 0.035$ and $3.6 \leq (e1+f1) \leq 4.4$:

$$Eu_{a2}Mn_{b2}Mg_{c2}M^{12}{}_{d2}M^{22}O_{e2}Z^{2}{}_{f2} \qquad [3]$$

wherein M^{12} represents at least one element selected from the group consisting of a monovalent element, a divalent element except Eu, Mn and Mg, a trivalent element and a pentavalent element, in which the proportion of the divalent element is 80 mol% or more, the proportion of the sum of Ba, Ca and Sr is 40mol% or more, and the ratio (molar ratio) of Ca to the sum of Ba and Ca is less than 0.2; M^{22} represents a group of

tetravalent elements containing Si and Ge in a total amount of 90 mol% or more; Z^2 is at least one element selected from the group consisting of a minus monovalent and minus divalent elements, H and N; and a2 is a number satisfying $0.0003 \leq a2 \leq 0.8$, b2 is a number satisfying $0 < b2 \leq 0.8$, c2 and d2 are numbers satisfying $0 < c2/(c2+d2) \leq 0.2$ or $0.3 \leq c2/(c2+d2) \leq 0.8$, a2, b2 c2 and d2 are numbers satisfying $1.8 \leq (a2+b2+c2+d2) \leq 2.2$, and e2 and f2 are numbers satisfying $0 \leq f2/(e2+f2) \leq 0.035$ and $3.6 \leq (e2+f2) \leq 4.4$.

2. A phosphor comprising a crystal phase having a chemical composition of said formula [1], wherein M^{10} is a divalent element containing 85 mol% or more of at least one element selected from the group consisting of Ba, Ca and Sr, in which the ratio (molar ratio) of Ca to the sum of Ba and Ca is from 0.2 to 0.8; M^{20} represents at least one element selected from the group consisting of a monovalent, trivalent and pentavalent elements; M^{30} is Si; Z is at least one element selected from the group consisting of a minus monovalent and minus divalent elements, H and N; and a0 is a number satisfying $0.02 < a0 \leq 0.5$, b0 is a number satisfying $0 < b0 \leq 0.7$, c0 and d0 are numbers satisfying $0 \leq d0/(c0+d0) \leq 0.1$, a0, b0 c0 and d0 are numbers satisfying $1.9 \leq (a0+b0+c0+d0) \leq 2.1$, and e0 and f0 are numbers satisfying $0 \leq f0/(e0+f0) \leq 0.01$ and $3.8 \leq (e0+f0) \leq 4.2$.

3. A phosphor comprising a crystal phase having a chemical composition of said formula [2], wherein M^{11} represents at least one element selected from the group consisting of a monovalent element, a divalent element except Eu, Mn and Mg, a trivalent element and a pentavalent element, in which at least one element selected from the group consisting of Ba, Ca and Sr is contained in an amount of 85mol% or more, and the ratio (molar ratio) of Ca to the sum of Ba and Ca is from 0.2 to 0.8; M^{21} is Si; Z is at least one element selected from the group consisting of a minus monovalent and minus divalent elements, H and N; and a1 is a number satisfying $0.01<a1\leq0.5$, b1 is a number satisfying $0<b1\leq0.7$, c1 and d1 are numbers satisfying $0\leq d1/(c1+d1)\leq0.2$, a1, b1 c1 and d1 are numbers satisfying $1.9\leq(a1+b1+c1+d1)\leq2.1$, and e1 and f1 are numbers satisfying $0\leq f1/(e1+f1)\leq0.01$ and $3.8\leq(e1+f1)\leq4.2$.

4. A phosphor comprising a crystal phase having a chemical composition of said formula [3], wherein M^{12} represents at least one element selected from the group consisting of a monovalent element, a divalent element except Eu, Mn and Mg, a trivalent element and a pentavalent element, in which the proportion of the divalent element is 80 mol% or more, the proportion of the sum of Ba, Ca and Sr is 40mol% or more, and the ratio (molar ratio) of Ca to the sum of Ba and Ca is less than 0.2; M^{22} represents a group of tetravalent

elements containing Si and Ge in a total amount of 90 mol% or more; Z is at least one element selected from the group consisting of a minus monovalent and minus divalent elements, H and N; and a2 is a number satisfying $0.01<a2\leq 0.5$, b2 is a number satisfying $0<b2\leq 0.8$, c2 and d2 are numbers satisfying $0<c2/(c2+d2)\leq 0.2$ or $0.3\leq c2/(c2+d2)\leq 0.7$, a2, b2 c2 and d2 are numbers satisfying $1.9\leq(a2+b2+c2+d2)\leq 2.1$, and e2 and f2 are numbers satisfying $0\leq f2/(e2+f2)\leq 0.01$ and $3.8\leq(e2+f2)\leq 4.2$.

5. The phosphor according to any one of claims 1 to 4, wherein the phosphor comprises a specified crystal phase obtained from X-ray diffraction measurement, wherein the crystal phase satisfies the following conditions:

(Conditions)

In X-ray diffraction measurement using a CuKα as an X-ray source, a diffraction peak is observed within the range (R0) of the diffraction angle (2θ) of from 21.30° to 22.50°, and when this diffraction peak is taken as a reference diffraction peak (P0) and 5 diffraction angle ranges derived from the Bragg angle (θs) of P0 are taken as R1, R2, R3, R4 and R5, at least one diffraction peak exists in these 5 ranges, with the proviso that P0 has an intensity of 20% or more by the diffraction peak height ratio, based on the strongest diffraction peak of said 6 or more crystal phase-derived diffraction peaks, and the other peaks has an intensity of 9%

or more by the diffraction peak height ratio, wherein when two or more diffraction peaks exist in one angle range, a peak higher in intensity is selected.

R1: $2\times\arcsin\{\sin(\theta 0)/(0.720\times 1.015)\}$ to $2\times\arcsin\{\sin(\theta 0)/(0.720\times 0.985)\}$

R2: $2\times\arcsin\{\sin(\theta 0)/(0.698\times 1.015)\}$ to $2\times\arcsin\{\sin(\theta 0)/(0.698\times 0.985)\}$

R3: $2\times\arcsin\{\sin(\theta 0)/(0.592\times 1.015)\}$ to $2\times\arcsin\{\sin(\theta 0)/(0.592\times 0.985)\}$

R4: $2\times\arcsin\{\sin(\theta 0)/(0.572\times 1.015)\}$ to $2\times\arcsin\{\sin(\theta 0)/(0.572\times 0.985)\}$

R5: $2\times\arcsin\{\sin(\theta 0)/(0.500\times 1.015)\}$ to $2\times\arcsin\{\sin(\theta 0)/(0.500\times 0.985)\}$

6. The phosphor according to any one of claims 1 to 4, wherein said crystal phase satisfies the following conditions:

(Conditions)

In X-ray diffraction measurement using a CuKα as an X-ray source, a diffraction peak is observed within the range (R0) of the diffraction angle (2θ) from 21.30° to 22.50°, and when this diffraction peak is taken as a reference diffraction peak (P0) and 5 diffraction angle ranges derived from the Bragg angle (θs) of P0 are taken as R1, R2, R3, R4 and R5, at least one diffraction peak exists in these 5 ranges, with the proviso that P0 has an intensity of 20% or more by the diffraction peak

height ratio, based on the strongest diffraction peak of 6 or more H1-derived diffraction peaks, and the other peaks has an intensity of 9% or more by the diffraction peak height ratio, wherein when two or more diffraction peaks exist in one angle range, a peak higher in intensity is selected.

R1: $2\times\arcsin\{\sin(\theta 0)/(0.720\times 1.010)\}$ to $2\times\arcsin\{\sin(\theta 0)/(0.720\times 0.990)\}$

R2: $2\times\arcsin\{\sin(\theta 0)/(0.698\times 1.010)\}$ to $2\times\arcsin\{\sin(\theta 0)/(0.698\times 0.990)\}$

R3: $2\times\arcsin\{\sin(\theta 0)/(0.592\times 1.010)\}$ to $2\times\arcsin\{\sin(\theta 0)/(0.592\times 0.990)\}$

R4: $2\times\arcsin\{\sin(\theta 0)/(0.572\times 1.010)\}$ to $2\times\arcsin\{\sin(\theta 0)/(0.572\times 0.990)\}$

R5: $2\times\arcsin\{\sin(\theta 0)/(0.500\times 1.010)\}$ to $2\times\arcsin\{\sin(\theta 0)/(0.500\times 0.990)\}$

7. A phosphor comprising a crystal phase of an alkali earth silicate containing at least one element selected from the group consisting of Ba, Sr, Ca and Mg, wherein said crystal phase is a crystal phase satisfying the following conditions:

(Conditions)

In X-ray diffraction measurement using a CuKα as an X-ray source, a diffraction peak is observed within the range (R0) of the diffraction angle (2θ) from 21.30° to 22.50°, and when this diffraction peak is taken as a reference diffraction

peak (P0) and 5 diffraction angle ranges derived from the Bragg angle (θs) of P0 are taken as R1, R2, R3, R4 and R5, at least one diffraction peak exists in these 5 ranges, with the proviso that P0 has an intensity of 20% or more by the diffraction peak height ratio, based on the strongest diffraction peak of said 6 or more crystal phase-derived diffraction peaks, and the other peaks has an intensity of 9% or more by the diffraction peak height ratio, wherein when two or more diffraction peaks exist in one angle range, a peak higher in intensity is selected.

R1: $2\times\arcsin\{\sin(\theta 0)/(0.720\times 1.010)\}$ to $2\times\arcsin\{\sin(\theta 0)/(0.720\times 0.990)\}$

R2: $2\times\arcsin\{\sin(\theta 0)/(0.698\times 1.010)\}$ to $2\times\arcsin\{\sin(\theta 0)/(0.698\times 0.990)\}$

R3: $2\times\arcsin\{\sin(\theta 0)/(0.592\times 1.010)\}$ to $2\times\arcsin\{\sin(\theta 0)/(0.592\times 0.990)\}$

R4: $2\times\arcsin\{\sin(\theta 0)/(0.572\times 1.010)\}$ to $2\times\arcsin\{\sin(\theta 0)/(0.572\times 0.990)\}$

R5: $2\times\arcsin\{\sin(\theta 0)/(0.500\times 1.010)\}$ to $2\times\arcsin\{\sin(\theta 0)/(0.500\times 0.990)\}$

8. A light emitting device comprising a first light emitter which emits light of 350 nm to 430 nm and a second light emitter which emits visible light by irradiation of light from the first light emitter, wherein the second light emitter

contains the phosphor according to any one of claims 1 to 7.

9. The light emitting device according to claim 8, wherein the first light emitter is a laser diode or a light emitting diode.

10. A lighting system comprising the light emitting device according to claim 8 or 9.

11. An image display unit comprising the light emitting device according to claim 8 or 9.